

NIST TIME AND FREQUENCY BULLETIN  
NISTIR 6630-08

NO. 560 AUGUST 2004

1. GENERAL BACKGROUND INFORMATION .....	2
2. TIME SCALE INFORMATION .....	2
3. PHASE DEVIATIONS FOR WWVB AND LORAN-C .....	4
4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS .....	5
5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS .....	5
6. BIBLIOGRAPHY .....	5
7. SPECIAL ANNOUNCEMENTS .....	7

This bulletin is published monthly. Address correspondence to:

Eyvon M. Petty, Editor  
Time and Frequency Division  
National Institute of Standards and Technology  
325 Broadway  
Boulder, CO 80305-3328  
(303) 497-3295  
Email: [pettye@boulder.nist.gov](mailto:pettye@boulder.nist.gov)



---

U.S. DEPARTMENT OF COMMERCE, DONALD L. EVANS, Secretary  
TECHNOLOGY ADMINISTRATION, Phillip J. Bond, Under Secretary of Commerce for Technology  
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, Arden L. Bement, Jr., Director

## 1. GENERAL BACKGROUND INFORMATION

### ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

ACTS	- Automated Computer Time Service		
BIPM	- Bureau International des Poids et Mesures		
Cs	- Cesium standard		
GPS	- Global Positioning System		
IERS	- International Earth Rotation Service		
LORAN	- Long Range Navigation		
MC	- Master Clock		
MJD	- Modified Julian Date		
NVLAP	- National Voluntary Laboratory Accreditation Program		
NIST	- National Institute of Standards and Technology		
NOAA	- National Oceanic and Atmospheric Administration	ns	- nanosecond
SI	- International System of Units	μs	- microsecond
TA	- Atomic Time	ms	- millisecond
TAI	- International Atomic Time	s	- second
USNO	- United States Naval Observatory	min	- minute
UTC	- Coordinated Universal Time		

## 2. TIME SCALE INFORMATION

The values listed below are based on data from the IERS, the USNO, and NIST. The UTC(USNO,MC) - UTC(NIST) values are averaged measurements from all available common-view GPS satellites (see bibliography on page 5). **UTC - UTC(NIST) data are on page 3.**

0000 HOURS COORDINATED UNIVERSAL TIME			
JUL 2004	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
1	53187	-469 ms	-1 ns
8	53194	-466 ms	-1 ns
15	53201	-462 ms	-2 ns
22	53208	-471 ms	-3 ns
29	53215	-456 ms	0 ns

The master clock pulses used by the WWV, WWVH, and WWVB time-code transmissions are referenced to the UTC(NIST) time scale. Occasionally, 1 s is added to the UTC time scale. This second is called a leap second. Its purpose is to keep the UTC time scale within ±0.9 s of the UT1 astronomical time scale, which changes slightly due to variations in the Earth's rotation.

**NOTE: No leap second will be added at the end of December 2004.**

Positive leap seconds, beginning at 23 h 59 min 60 s UTC and ending at 0 h 0 min 0 s UTC, were inserted in the UTC timescale on 30 June 1972, 1981-1983, 1985, 1992, 1993, 1994, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990, 1995, and 1998.

The use of leap seconds ensures that UT1 - UTC will always be held within ±0.9 s. The current value of UT1 - UTC is called the DUT1 correction. DUT1 corrections are broadcast by WWV, WWVH, WWVB, and ACTS and are printed below. These corrections may be added to received UTC time signals in order to obtain UT1.

DUT1 = UT1 - UTC =	+0.0 s beginning 0000 UTC 01 March 2001
	-0.1 s beginning 0000 UTC 04 October 2001
	-0.2 s beginning 0000 UTC 14 February 2002
	-0.3 s beginning 0000 UTC 24 October 2002
	-0.4 s beginning 0000 UTC 03 April 2003
	-0.5 s beginning 0000 UTC 29 April 2004

The difference between UTC(NIST) from UTC has been within  $\pm 100$  ns since July 6, 1994. The table below shows values of UTC - UTC(NIST) as supplied by the BIPM in their Circular T publication for the most recent 310-day period in which data are available. Data are given at ten-day intervals. Five-day interval data are available in Circular T.

**0000 Hours Coordinated Universal Time**

DATE	MJD	UTC-UTC(NIST) ns
Jun. 23, 2004	53179	-6.4
Jun. 13, 2004	53169	-5.2
Jun. 03, 2004	53159	0.2
May 24, 2004	53149	5.4
May 14, 2004	53139	9.9
May 04, 2004	53129	10.5
Apr. 24, 2004	53119	7.5
Apr. 14, 2004	53109	6.9
Apr. 04, 2004	53099	6.7
Mar. 25, 2004	53089	6.3
Mar. 15, 2004	53079	4.1
Mar. 05, 2004	53069	3.2
Feb. 24, 2004	53059	1.2
Feb. 14, 2004	53049	-2.0
Feb. 4, 2004	53039	-4.5
Jan. 25, 2004	53029	-4.6
Jan. 15, 2004	53019	-4.2
Jan. 5, 2004	53009	-3.1
Dec. 26, 2003	52999	-4.0
Dec. 16, 2003	52989	-2.8
Dec. 6, 2003	52979	-0.2
Nov. 26, 2003	52969	-1.1
Nov. 16, 2003	52959	2.0
Nov. 6, 2003	52949	2.1
Oct. 27, 2003	52939	1.8
Oct. 17, 2003	52929	1.2
Oct. 7, 2003	52919	3.9
Sep. 27, 2003	52909	7.9
Sep. 17, 2003	52899	7.5
Sep. 7, 2003	52889	7.6

### 3. PHASE DEVIATIONS FOR WWVB AND LORAN-C

WWVB - The values shown for WWVB are the time differences between the time markers of the UTC(NIST) time scale and the first positive-going zero voltage crossover measured at the transmitting antenna. The uncertainty of the individual measurements is  $\pm 0.5 \mu\text{s}$ . The values listed are for 1300 UTC.

LORAN-C - The values shown for Loran-C represent the daily accumulated phase shift (in ns). The phase shift is measured by comparing the output of a Loran receiver to the UTC(NIST) time scale for a period of 24 h. If data were not recorded on a particular day, the symbol (-) is printed. The stations monitored are Baudette, ND (8970-Y) and Fallon, NV (9940). The monitoring is done from the NIST laboratories in Boulder, Colorado.

**Note: The values shown for Loran-C are in nanoseconds.**

DATE	MJD	UTC(NIST)-WWVB (60 kHz)	UTC(NIST) - LORAN PHASE (ns)	
		ANTENNA PHASE ( $\mu\text{s}$ )	LORAN-C (BAUDETTE) (8970)	LORAN-C (FALLON) (9940)
07/01/04	53187	5.78	-197	+10
07/02/04	53188	5.77	+177	-27
07/03/04	53189	5.78	-26	+145
07/04/04	53190	5.90	+262	+170
07/05/04	53191	5.90	-246	-180
07/06/04	53192	5.80	-109	+153
07/07/04	53193	5.80	+154	+7
07/08/04	53194	5.81	+8	+73
07/09/04	53195	5.81	-120	-232
07/10/04	53196	5.81	+12	+22
07/11/04	53197	5.81	-9	+186
07/12/04	53198	5.82	-183	+290
07/13/04	53199	5.82	+295	-346
07/14/04	53200	5.84	-414	-73
07/15/04	53201	5.83	-7	-56
07/16/04	53202	5.83	-150	+258
07/17/04	53203	5.81	+9	-232
07/18/04	53204	5.82	+56	+170
07/19/04	53205	5.83	-2	+357
07/20/04	53206	5.82	+346	-55
07/21/04	53207	5.82	+82	+419
07/22/04	53208	5.85	-153	-53
07/23/04	53209	5.83	+15	+193
07/24/04	53210	5.83	-267	+321
07/25/04	53211	5.83	+34	+215
07/26/04	53212	5.84	+26	-145
07/27/04	53213	5.83	+207	-28
07/28/04	53214	5.85	-95	+15
07/29/04	53215	5.83	-303	+171
07/30/04	53216	5.77	+185	+74
07/31/04	53217	5.76	-197	+23

#### 4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

NIST Radio Station WWVB expected to operate at reduced power during the period approximately July 26 to August 2, 2004. NIST will be conducting major repairs on one of the two antenna arrays used to broadcast WWVB signals that automatically set radio-controlled timepieces to NIST time. During this repair period, we expect that WWVB will be broadcasting at about half the normal power. This reduced power may prevent some radio-controlled timepieces from synchronizing to NIST time during the repair period, particularly those timepieces located furthest from the Colorado radio station. However, the timepieces will resynchronize to NIST time when the repairs are completed and full power broadcasting is restored. The period of reduced power broadcasting may vary slightly from the planned period of July 26 to August 2 depending on uncontrollable factors such as weather which may hinder repairs. We will update this message should the planned reduced power period change.

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	JULY 2004	MJD	Began UTC	Ended UTC	Freq.	JULY 2004	MJD	Began UTC	End UTC
WWVB	07/09/04	53195	1121	1154	60 kHz				
WWVB	07/05/04	53191	1915	2025	60 kHz				
WWVB	07/04/04	53190	1917	2004	60 kHz				
WWV									

#### 5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS

Primary frequency standards developed and operated by NIST are used to provide accuracy (rate) input to the BIPM. NIST-7 was the U.S. primary standard from 1994 to 1999, when it was replaced by NIST-F1, a cold-atom cesium fountain frequency standard. The uncertainty of NIST-F1 is currently about 1 part in  $10^{15}$ .

The AT1 scale is run in real-time by use of data from an ensemble of cesium standards and hydrogen masers. It is a free-running scale whose frequency is maintained as nearly constant as possible by choosing the optimum weight for each clock that contributes to the computation.

UTC(NIST) is generated as an offset from our real-time scale AT1. It is steered in frequency towards UTC by use of data published by the BIPM in its Circular T. Changes in the steering frequency will be made, if necessary, at 0000 UTC on the first day of the month, and occasionally at mid-month. A change in frequency is limited to no more than  $\pm 2$  ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM using a post-processed time-scale algorithm and is not available in real-time. The parameters that we use to generate UTC(NIST) in real-time are therefore based on an extrapolation of UTC from the most recent available data.

#### 6. BIBLIOGRAPHY

- Allan, D.W.; Hellwig, H.; and Glaze, D.J., "An accuracy algorithm for an atomic time scale," *Metrologia*, Vol.11, No.3, pp.133-138 (1975).
- Allan, D.W.; Davis, D.D.; Weiss, M.A.; Clements, A.; Guinot, B.; Granveaud, M.; Dorenwendt, K.; Fischer, B.; Hetzel, P.; Aoki, S.; Fujimoto, M.; Charron, L.; and Ashby, N., "Accuracy of International Time and Frequency Comparisons Via Global Positioning System Satellites in Common-view," *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-34, pp.118-125, 1985.
- Jefferts, S.R.; Shirley, J.; Parker, T.E.; Heavner, T.P.; Meekhof, D.M.; Nelson, C.; Levi, F.; Costanza, G.; De Marchi, A.; Drullinger, R.; Hollberg, L.; Lee, W.D.; and Walls, F.L., "Accuracy evaluation of NIST-F1," *Metrologia*, Vol. 39, pp. 321-336, (2002).
- Lewandowski, W. and Thomas, C.; "GPS Time transfer," *Proceedings of the IEEE*, Vol. 79, pp. 991-1000, 1991.
- Shirley, J.H.; Lee, W.D.; Drullinger, R.E.; "Accuracy evaluation of the primary frequency standard NIST-7," *Metrologia*, Vol. 38, pp. 427-458, (2001).
- Weiss, M.A.; Allan, D.W.; "An NBS Calibration Procedure for Providing Time and Frequency at a Remote Site by Weighting and Smoothing of GPS Common View Data," *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-36, pp. 572-578, 1987.



Table 7.1 lists parameters that are used to define UTC(NIST) with respect to our real-time scale AT1. To find the value of UTC(NIST) - AT1 at any time T (expressed as a Modified Julian Day, including a fraction if needed), the appropriate equation to use is the one for which the desired T is greater than or equal to the entry in the  $T_0$  column and less than the entry in the last column. The values of  $x_s$ ,  $x$ , and  $y$  for that month are then used in the equation below to find the desired value. The parameters  $x$  and  $y$  represent the offset in time and in frequency, respectively, between UTC(NIST) and AT1; the parameter  $x_s$  is the number of leap seconds applied to both UTC(NIST) and UTC as specified by the IERS. Leap seconds are not applied to AT1.

<p>Table 7.1  <math>UTC(NIST) - AT1 = x_s + x + y \cdot (T - T_0)</math></p>					
Month	$x_s$ (s)	$x$ (ns)	$y$ (ns/d)	$T_0$ (MJD)	Valid until 0000 on: (MJD)
Sep 04	-32	-268332.05	-39.4*	53249	53279
Aug 04	-32	-267110.65	-39.4	53218	53249*
Jul 04	-32	-266716.65	-39.4	53208	53218
Jul 04	-32	-265892.4	-39.25	53187	53208†
Jun 04	-32	-265342.9	-39.25	53173	53187
Jun 04	-32	-264722.9	-38.75	53157	53173†
May 04	-32	-264064.15	-38.75	53140	53157
May 04	-32	-263514.65	-39.25	53126	53140†
Apr 04	-32	-263004.4	-39.25	53113	53126
Apr 04	-32	-262334.6	-39.4	53096	53113†
Mar 04	-32	-261783.0	-39.4	53082	53096
Mar 04	-32	-261110.65	-39.55	53065	53082†
Feb 04	-32	-259963.7	-39.55	53036	53065
Jan 04	-32	-259410.0	-39.55	53022	53036
Jan 04	-32	-258738.5	-39.5	53005	53022†
Dec 03	-32	-258343.5	-39.5	52995	53005
Dec 03	-32	-257516.1	-39.4	52974	52995†
Nov 03	-32	-256925.1	-39.4	52959	52974
Nov 03	-32	-256334.85	-39.35	52944	52959†
Oct 03	-32	-255783.95	-39.35	52930	52944
Oct 03	-32	-255112.45	-39.5	52913	52930†
Sep 03	-32	-253927.745	-39.5	52883	52913
Aug 03	-32	-252702.95	-39.5	52852	52883
Jul 03	-32	-252228.95	-39.5	52840	52852
Jul 03	-32	-251473.7	-39.75	52821	52840†

† Rate change in mid-month  
 †† Rate change one day early  
 \*Provisional value

## **7. SPECIAL ANNOUNCEMENTS**

### **NOTICE TO DISCONTINUE INVOLVEMENT WITH GOES TIME CODE SERVICE**

NIST and NOAA (National Oceanic and Atmosphere Administration) have announced that the GOES Time Code Service will end on January 1, 2005. Existing GOES Time Code receivers will no longer be able to synchronize after that date, since the time code will then be removed from the broadcast. This decision has been jointly made by NIST and NOAA in response to the fact that nearly all users requiring time more accurate than 1 millisecond now use the Global Positioning System (GPS), and as a result, commercial sources for GOES timing receivers have not existed for several years.

The GOES time broadcasts began in 1974 and have served many applications and thousands of users. The service works by providing a time code referenced to UTC(NIST) through two satellites (GOES EAST and GOES WEST) that are operated by NOAA. NIST will continue to control and monitor the time code through January 1, 2005 to allow existing GOES users sufficient time to replace their receivers.

For questions or more information contact Michael Lombardi at [lombardi@boulder.nist.gov](mailto:lombardi@boulder.nist.gov).

